User Manual

Bobcat-640-GigE&CL Camera

ENG-2012-UMN020-R002

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Revision History

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000.02	12/10/2012	Getting started chapter added and upgrade firmware added	CDU
000.03	31/10/2012	Tab 4.1: column added, chap. 4.2.1 Xenics TCP Protocol: new, chap. 4.3: screenshots added, chap 5.1: small update, chap 6.1: small update	CDU
000.04	23/11/2012	Camera features and functions (chapter 8) updated	JDS
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000.07	07/06/2013	GigE and CL combined in 1 User Manual Update Auto-exposure	JDS
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000.15	14/01/2014	Appendix Frame Rate Calculator added	CDU
000.16	16/01/2014	Added new mechanical drawings	JDH
000.17	30/01/2014	Specs updated	CDU
000.18	26/02/2014	New appendix H: Histogram Equalization added	CDU
000.19	28/02/2014	New issue of appendix XFPA-640 Control & Operation, new issue of appendix Auto Exposure Control and OPT-000062 deleted (Stingray)	CDU
000.20	11/03/2014	Getting Started updated	JDS
	12/03/2014	New issue of appendix Histogram Equalization	CDU
001	21/03/2014	First released issue	CDU
002	31/03/2014	Appendix mechanical drawing updated (EASM file removed) Second released issue	CDU

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Change Details

This table lists all changes of this issue compared to the previous released one.

Chapter/Section	Changes	Modified by

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List of Abbreviations

CC	Camera Control
CL	Cameralink
GigE	Gigabit Ethernet
PoE	Power over Ethernet
SDK	Software Development Kit
SWIR	Short Wave Infrared
XSW	Xenics Short Wave Module

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1. Introduction

1.1. Scope

This User Manual describes the technical specifications, dimensions, image processing, basic and advanced parameters and related subjects for the following cameras:

Camera	Part number	Description
Bobcat-640-GigE Scientific	XEN-000296	High resolution SWIR imaging Camera with TE1 stabilization and GigE interface
Bobcat-640-GigE Industrial	XEN-000298	High resolution SWIR imaging Camera with TE1 stabilization and GigE interface
Bobcat-640V-GigE Scientific	XEN-000099	High resolution VisNIR Imaging Camera with TE1 stabilization and GigE interface
Bobcat-640V-GigE Industrial	XEN-000139	High resolution VisNIR Imaging Camera with TE1 stabilization and GigE interface
Bobcat-640-CL Industrial	XEN-000297	High resolution SWIR imaging Camera with TE1 stabilization and CL interface
Bobcat-640V-CL Industrial	XEN-000140	High resolution VisNIR Imaging Camera with TE1 stabilization and CL interface

Table 1-1 Camera overview - Bobcat-640-GigE and Bobcat-640-GigE and CL

Target group: This technical manual is written for professional users.

i Please read this manual thoroughly before operating the camera!

1.2. Manual Overview

This section provides a chapter overview:

- Chapter 1 gives an overview of the conventions used in this manual (styles and symbols), the safety warnings, conformity information about Xenics cameras and the contact information.
- Chapter 2 gives a mechanical (2D drawings) and electrical overview
- Chapter 3 describes how to get started
- Chapter 4 describes the optical interfaces
- Chapter 5 describes the electrical interfaces
- Chapter 6 provides the installation of the Xeneth and SDK software
- Chapter 7 lists the appendices.

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1.3. Reference Documents

(Ref. 1)	Xenics Serial Protocol	ENG-2011-ICD003
(Ref. 2)	Mechanical Drawings GigE and CL	
(Ref. 3)	Auto Gain Control	ENG-2013-UMN006
(Ref. 4)	Auto Exposure Control	ENG-2012-UMN017
(Ref. 5)	XFPA-640 Control and Operation	ENG-2013-ICD007
(Ref. 6)	Network connection setup for GigE	ENG-2013-ICD003
(Ref. 7)	Frame Rate Calculator	ENG-2014-ICD001
(Ref. 8)	Histogram Equalization Control	ENG-2014-UMN002
(Ref. 9)	Xeneth Installation Manual (see Xeneth SW directory)	ENG-2013-UMN024

1.4. Conventions Used in This Manual

To give this manual an easily understood layout and to emphasize important information, the following typographical styles and symbols are used:

The styles used in this manual are:

- **Bold**: used for programs, inputs (commands or parameters) or highlighting important things
- `Courier New`: used for code listings and output.
- *Italics*: used for modes and fields.

The symbols used in this manual:

Note: This symbol highlights important information.

Warning: This symbol highlights important instructions. These instructions must be followed to avoid malfunctions!

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1.5. Safety Warnings

The following safety warnings must be followed:

Supply voltage polarity: Use the correct polarity of the 12 V supply voltage.

Warranty: The warranty becomes void in case of unauthorized tampering or any manipulations not approved by the manufacturer.

Electrostatic discharge: The camera contains sensitive electronic components which can be destroyed by means of electrostatic discharge. Use sufficient grounding to minimize the risk of damage.

Environmental conditions: Operate the camera in dry and dust free environment.
Regarding the signal quality of the camera it is an advantage to operate the camera under constant ambient air temperature (~20°C).
Beneath or above ambient temperature a sufficient heating or cooling may be necessary.

Warm-up Period: Depending on the prevailing environmental conditions, some time might pass after the camera start, until the image quality reaches its optimum.

1.6. Conformity

Xenics declares under its sole responsibility that all standard cameras of the Bobcat 640 family to which this declaration relates to, are conform with the following standard(s) or other normative document(s):

- CE, following the provisions of 2004/108/EG directive
- RoHS (2002/95/EC).

CE:
We declare, under our sole responsibility, that the previously described Bobcat cameras areconform to the CE directives.

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  Asian sales, manufacturing and custom solutions office
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- **Distributors worldwide**
  Xenics is a European based provider of infrared imaging products and has representatives and distributor locations around the world to service our many customers.

  Please visit our website for more contact details:
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2. Mechanical & Electrical Specifications

The mechanical drawings of Bobcat-640-GigE and CL can be found in Appendix B.

2.1. Bobcat-640 Detector Specifications

The detector specifications are summarized in Table 2-1.

Parameter	Specification	Unit
Sensor type	InGaAs FPA; ROIC with CTIA topology	
Spectral Band	0.9 to 1.7	µm
	Optional 0.4 to 1.7 (VisNIR)	µm
Array format	640x512	pixels
Pixel pitch	20	µm
Quantum Efficiency SWIR sensor (1)	80	%
Quantum Efficiency VisNIR sensor(2)	85	%
Dark Current (3)	$1.1x10^6$	electrons/s
ROIC Noise High Gain (3)	60	electrons
ROIC Noise Low Gain (3)	400	electrons
Integration Capacitor High Gain	6.7	fF
Integration Capacitor Low Gain	85	fF
Full Well High Gain	80×10^3	electrons
Full Well Low Gain	1.1×10^6	electrons
Pixel operability	>99	%
Cooling	TE1	

Table 2-1 Electro-optical detector specifications

(1) Typical value @ 1600nm
(2) Typical value @ 950nm
(3) Typical value, measured at 25°C FPA temperature

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2.2. Bobcat-640-GigE & CL Specifications

The camera specifications are listed in Table 2-2.

Feature	GigE	CL	Unit
Imaging performance			
Frame rate	100		Hz
Window of interest	Yes (minimal window: 32x4)		
Exposure time range	1-40000 (1)		µs
Gain (in High Gain mode)	1.28		electron/ADU
Gain (in Low Gain mode)	16.2		electron/ADU
Camera Read Noise Low Gain (4)	400		electrons rms
Camera Read Noise High Gain (4)	120		electrons rms
Dynamic Range Low Gain	68		dB
Dynamic Range High Gain	56		dB
Readout mode	Integrate Then Read (ITR) Integrate While Read (IWR)		
On-board image processing	- Imaging correction (fixed NUC for Bobcat-GigE, TrueNUC for Bobcat-CL), - Auto-Gain and Offset - Auto-Exposure (Only for Bobcat CL) - Trigger possibilities		
A to D conversion resolution	14		bit
Interfaces			
Image acquisition and Camera control	GigE Vision	Camera Link	
Trigger	In or out via SMA	In or out via SMA or CL-CC1	
Trigger-in delay	3.1 µs rising edge (SMA trigger) (5) 3.3 µs falling edge (SMA trigger) (5)	1.3 µs rising and falling edge (CC1 trigger) 3.1 µs rising edge (SMA trigger) (5) 3.3 µs falling edge (SMA trigger) (5)	µs
Trigger-in jitter	± 0.05		µs
Power Requirements			
Input Voltage	12±10%		V
Power consumption (2)	4	2.8	W
Physical characteristics			
Dimensions (3)	55x55x81.7	55x55x72	mm^3
Camera weight (3)	334 without lens	285 without lens	g
Environmental specifications			
Operating case temperature	-40 to 70		°C
Storage temperature	-45 to 85		°C
Vibration	4.3G (20 to 1000 Hz)		G
Shock	40G (11ms, half-sine profile)		G

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Table 2-2 Specifications Bobcat-640-GigE and CL

(1) At 25°C FPA temperature
(2) Typical value, measured without TEC
(3) Without Lens
(4) Typical value, measured in the dark at t_{exp} = 0.1ms and 25°C FPA temperature
(5) With trigger-in voltage = 5V.

i The design and specifications for the products described above may change without notice.

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3. Getting Started

The steps to start the Bobcat camera easily are described in this section.

3.1. Connect to the Camera using Xeneth

Perform the following steps to connect the camera when using Xeneth:

- Connect all necessary cables to the camera. For details about the electrical interface and cables: see chap. 5.
- Install Xeneth on the PC. For more information see chap. 6 & (Ref. 9).
    - For the Bobcat CL, make sure that the frame grabber is installed properly.
    - For the Bobcat GigE, see also (Ref. 6) for more information related to the network connection.
- Start Xeneth by clicking the Xeneth shortcut on the desktop to start up Xeneth (see Figure 3-1). The connection dialog will become visible (see Figure 3-2). When the camera is not shown, click the refresh button on the dialog. Select the camera, together with the calibration data suited for it. For more details, consult the Xeneth User Manual, section Connection setup - Settings.
- Select the camera in the Connection Setup window (see Figure 3-2).
- Select the calibration pack to be loaded (see Figure 3-2).
    - To use a calibration pack in software, select the name of the calibration pack
    - To use the onboard calibration use: <Camera memory>.
    - Press <Connect> to connect to the camera.
- Press <Start Capturing> to start grabbing frames (see Figure 3-3).

Figure 3-1 Xeneth shortcut

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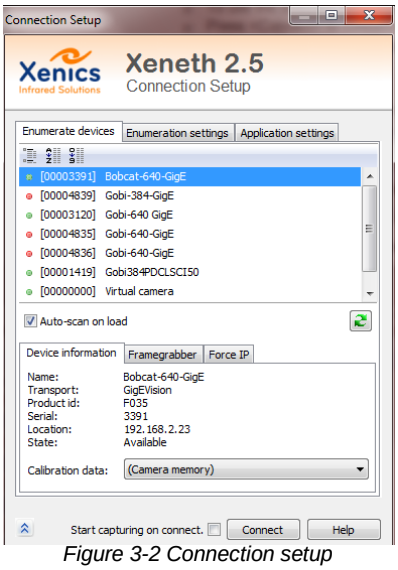

Figure 3-2 Connection setup

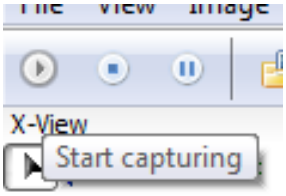

Figure 3-3 Start capturing

3.2. Bobcat GigE: Camera Properties and Corrections

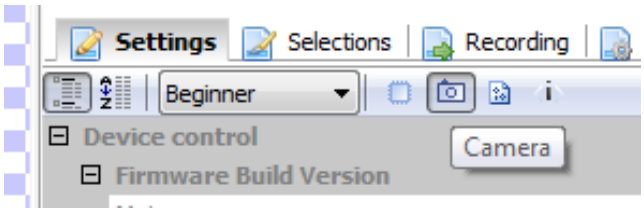

Figure 3-4 Access the camera properties

3.2.1. Change Camera Properties

Perform the following steps to change the camera properties:

- To change the camera properties, press the <Camera> icon (see Figure 3-4).
- When using the camera for the first time, use the Beginner mode (see Figure 3-4).
- In the beginner mode, the following properties can be modified by the user. For more information on the camera properties, see (Ref. 3), (Ref. 4), (Ref. 5) and (Ref. 8), or click on the property (Right-button-click) and select <Show property documentation>.
    - Device control:
        - Device gain: High Gain or Low Gain to set the feedback capacitor value (6.7fF or 85fF) of the CTIA readout. See also (Ref. 5)
        - Temperature: (read only): this value gives the temperature of the focal plane array.
    - Acquisition control

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- Exposure time: Sensor exposure time.
- Integration mode: ITR (Integrate then read) or IWR (Integrate while read). Note that the ITR mode gives in general a better image quality. Only for long exposure times (>10000us), it is adviced to use IWR, in order to obtain a higher framerate.

o Image processing control
- Auto gain control: see also (Ref. 3)
- Offset Control: automatic or manual offset control
- Gain Control: automatic or manual gain control
- Offset used: offset used by the auto-gain&offset algorithm
- Gain used: gain used by the auto-gain&offset algorithm
- Manual mode control: when the manual mode is selected, the gain and offset can be manually set.

o GigE Vision Transport Layer.

3.3. Use of Correction Files

Perform the following to use the non-uniformity correction (NUC) files:

- To apply a correction in Xeneth **software:** click the <Select> button and select a different correction file. Note that the fixed NUC files are only valid for a fixed exposure time (at the specified sensor temperature and integration mode). The TrueNUC files are valid for a range of exposure times (at the specified sensor temperature and integration mode). In this case, a new offset image is calculated whenever the exposure time is changed. In this way, the dark current variation with exposure time is taken into account.

- To upload and use a **correction file onboard** of the camera**,** perform the following steps **(only possible for fixed NUC correction files):**
  - o In Xeneth: go to the Settings tab / Storage icon (see Figure 3-5)
  - o Upload the correction file:
    - Click on Correction file property and then on the green upload arrow on the right (see Figure 3-6).
    - Select the new correction file.
    - Wait till the file is transferred to the camera (= wait until Xenics logo disappears: see Figure 3-7).
  - o Reconnect to the camera to activate the new correction file. While reconnecting, choose ‘camera memory’ calibration data (see Figure 3-8).
- The correction can be enabled and disabled using the **enable image correction button** (see Figure 3-9).

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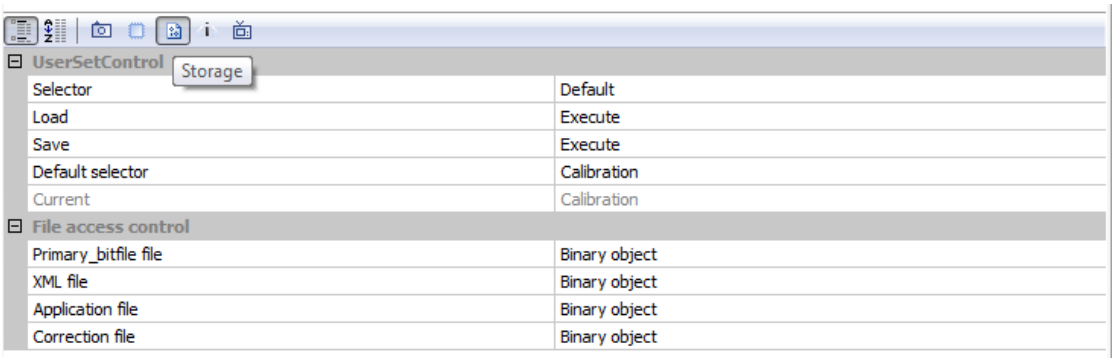

Figure 3-5 Correction pack upload: storage icon

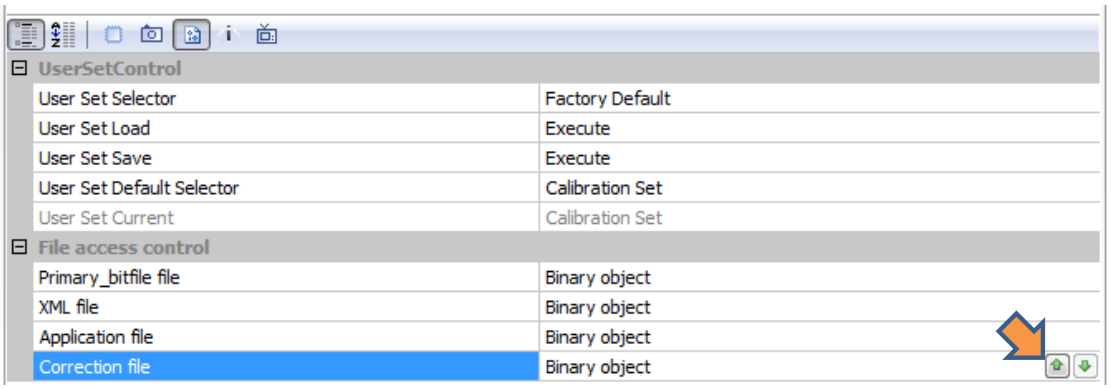

Figure 3-6 Correction file upload

Figure 3-7 Xenics logo while correction file upload

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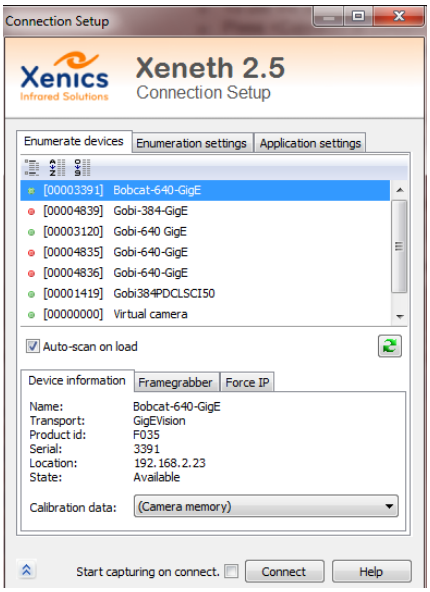

Figure 3-8 Reconnect to camera with onboard correction

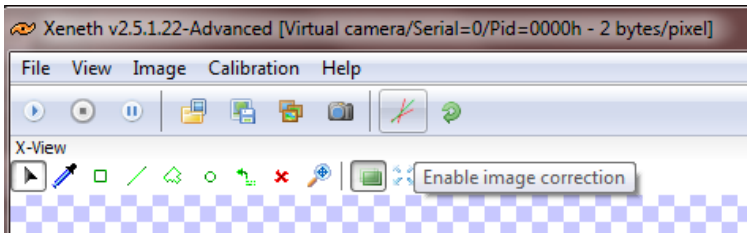

Figure 3-9 Enable image correction

3.4. Bobcat-CL: Camera Properties and Corrections

3.4.1. Change Camera Properties

Perform the following steps to change the camera properties:

- To change the camera properties, press the <Camera> icon (see Figure 3-4).
- When using the camera for the first time, use the Beginner mode (see Figure 3-4).
- In the beginner mode, the following properties can be modified by the user. For more information on the camera properties, see (Ref. 3), (Ref. 4), (Ref. 5) and (Ref. 8), or click on the property (Right-button-click) and select <Show property documentation>.
    - Device control:
        - Device gain: High Gain or Low Gain to set the feedback capacitor value (6.7fF or 85fF) of the CTIA readout. See also (Ref. 5)
        - Temperature: (read only): this value gives the temperature of the focal plane array.
    - Acquisition control

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- Exposure time: Sensor exposure time. Note that the sensor exposure time register is only active when the auto-exposure algorithm is disabled.
- Integration mode: ITR (Integrate then read) or IWR (Integrate while read). Note that the ITR mode gives in general a better image quality. Only for long exposure times (>10000us), it is adviced to use IWR, in order to obtain a higher framerate.

o Image correction control
- True nuc control: when enabled, the onboard true nucs will be used (together with the dedicated bias settings) for image correction, at the specified integration mode and exposure time. (Note that there are 3 true nucs onboard: low gain/ITR, high gain/ITR and high gain/IWR.)

o Image processing control
- Auto gain control: see also (Ref. 3)
- Offset Control: automatic or manual offset control
- Gain Control: automatic or manual gain control
- Offset used: offset used by the auto-gain&offset algorithm
- Gain used: gain used by the auto-gain&offset algorithm
- Manual mode control: when the manual mode is selected, the gain and offset can be manually set.
- Histogram equalization control: to enable or disable the histogram equalization algorithm: See also (Ref. 8).
- Auto exposure control: to enable or disable the auto-exposure algorithm: See also (Ref. 4). When enabled, the actual exposure time used, the integration mode and gain can be found in the auto exposure status control registers.

3.4.2. Use of Correction Files

Perform the following to use the non-uniformity correction (NUC) files:

- To apply a correction in Xeneth **software:** press the <Select> button and select a different correction file. Note that the fixed NUC files are only valid for a fixed exposure time (at the specified sensor temperature and integration mode). The TrueNUC files are valid for a range of exposure times (at the at the specified sensor temperature and integration mode). In this case, a new offset image is calculated whenever the exposure time is changed. In this way, the dark current variation with exposure time is taken into account.

- The Bobcat-CL has also 3 TrueNUC correction files onboard:
  - Low Gain ITR: from 100us to 20ms
  - High Gain ITR: from 100us to 10ms
  - High Gain IWR: from 10ms to 40ms

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To use a **TrueNUC correction files onboard** of the camera**,** perform the following steps**:**

- Reconnect to the camera to activate the onboard correction. While reconnecting, choose 'camera memory' calibration data (see Figure 3-8).
- **Enable the TrueNUC control register**
- The correction can be enabled and disabled using the **enable image correction button** (see Figure 3-9).
- Select the desired integration mode and exposure time, or use the auto-exposure mode.

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4. Optical Interface

The optical interface of the camera consists of three parts: the front panel, a lens insert and the lens itself.

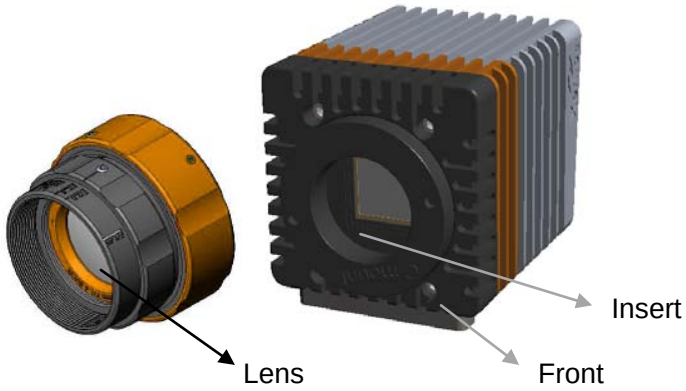

Figure 4-1 Optical components: lens - insert - front

A list of all possible lenses is shown in Table 4-1.

Lens configuration		Bobcat-640-GigE & CL
VIS lens 50mm f/0.95	OPT-000031	x
SWIR lens 50mm f/2.0 + mount/filter holder	ASY-000657	x
SWIR lens 75mm f/2.0 + mount/filter holder	ASY-000443	x
SWIR lens 100mm f/2.0 + mount/filter holder	ASY-000444	x
SWIR lens 200mm f/2.4 + mount/filter holder	ASY-000658	x
C-mount extender rings	OPT-000119	x

Table 4-1 Lens configuration

It is possible to use the following different solvents to clean a lens:

- Ethanol: removal of fingerprints and other contaminants
- Alcohol: final cleaning before use.

Perform the following steps to clean a lens:

1. Immerse lens tissue in Alcohol / Propanol or Ethanol (reagent grade).
2. Wipe the lens in "S" motion in such way that each lens area will not be wiped more than once!
3. Repeat stage 2 until the lens is clean. Use a new lens tissue each time!

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5. Electrical Interface

5.1. General Overview Connectors and Specifications

Interface	Connector	Specification	Camera Protocol
Bobcat-640-GigE			
Input power (12V DC)	Hirose HR10-7R-4SA(73)	12V ±10%	
Trigger (either Trigger-in or Trigger-out!)	SMA	Trigger in: $V_{IN,L}$ = 0.8V Max. $V_{IN,H}$ = 2V Min. $V_{IN,MAX}$ = 30V Internal Pull-down: R = 10kΩ	
		Trigger out: V_{HIGH} = 3.3V ±10% V_{LOW} = 0V	
Ethernet	RJ45 connector	GigE standard	GigE Vision
Bobcat -640-CL			
Input power (12V DC)	Hirose HR10-7R-4P(73)	12V ±10%	
Trigger (either Trigger-in or Trigger-out!)	SMA	Trigger in: $V_{IN,L}$ = 0.8V Max. $V_{IN,H}$ = 2V Min. $V_{IN,MAX}$ = 30V Internal Pull-down: R = 10kΩ	
		Trigger out: V_{HIGH} = 3.3V ±10% V_{LOW} = 0V	
Mini-camera link	CONN SDR 26POS VERT RECEPT	Serial control: 115200 baud, 8n1 Levels: RS-644	XSP Protocol (see (Ref. 1))
		Image acquisition: CL	CL Base protocol/ 1 TAP for image acquisition

Table 5-1 Electrical interface specifications for Bobcat-640-GigE, CL interface

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5.2. Power Interface

The power cable must be connected to the backside of the camera (see (Ref. 2) for its location). Figure 5-1 lists the connector pins overview. Table 5-2 shows schematically the pin location.

For a Bobcat-640-GigE, the power cable does not need to be connected to the camera in case Power over Ethernet (PoE) is used.

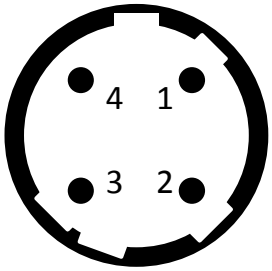

Figure 5-1 Camera power connector

Pin	Signal
1	+ 12V
2	+ 12V
3	Gnd
4	Gnd

Table 5-2 Camera power connector $12V_{DC}$

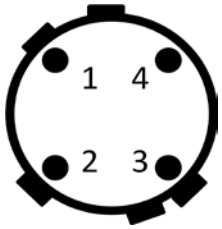

Figure 5-2 Cable connector

Pin	Signal
1	+ 12V
2	+ 12V
3	Gnd
4	Gnd

Table 5-3 Cable connector $12V_{DC}$

The power cable (ASY-001268) must be connected to the backside of the camera. Table 5-3 lists the connector pins overview. Figure 5-2 shows schematically the pin location of the cable connector (Hirose HR10-7P-4P(73)).

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5.3. Trigger Interface

Do not apply voltages to the trigger connector when it is configured in Trigger-OUT mode, because this will damage the camera!

For the trigger interface, a SMA connector is foreseen.

The trigger interface can be configured either as **Trigger-IN** or **Trigger-OUT**. The following settings can be customized:

- Trigger OUT
  - Polarity:
    - High
    - Low.
  - Width
  - Delay.
- Trigger-IN
  - Sensitivity
    - Level
    - Edge.
  - Polarity:
    - Low level / falling edge
    - High level / rising edge.
  - Delay
  - Trigger skip-count.

For more information on the trigger configuration see chap. (Ref. 5).

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5.4. GigE Interface

GigE Vision® is a camera interface standard that uses the Gigabit Ethernet (GigE) communication protocol. It provides a framework for transmitting high-speed video and related control data over Ethernet networks.

To realize the GigE communication the Bobcat-640-GigE cameras are equipped with a 1000Base-T Ethernet interface (RJ-45 connector). The data connection between camera and PC can be established via a standard CAT5e cable.

The GigE Vision standard defines how compliant products interact to deliver video and control information over Ethernet networks. It has the following four main elements:

- **Device discovery**: defines the sequence of events required for compliant devices to obtain valid Internet Protocol addresses, and for control applications to discover compliant devices.
- **GigE Vision control protocol (GVCP)**: defines how to specify video stream channels and control and configure compliant devices.
- **GigE Vision stream protocol (GVSP)**: defines how images are packetized and provides mechanisms for cameras or other types of video transmission systems to send image data and other information to compliant receivers.
- **An extensible mark-up language (XML) description file**: provides the equivalent of a computer-readable data sheet of features in compliant devices. This file must be based on standard defined by the European Machine Vision Association'sGenICam™.

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5.5. Camera Link Interface

Camera Link is an interface for the transfer of digital video data. The standard defines data transfer on a physical base and determines connectors, cables and components for transmission and reception. Different configurations are available, distinguishing between the numbers of parallel transferred data bits.

For the Bobcat-640-CL camera, the **BASE configuration with 1 TAP** is used. The pin assignment and pin lay-out of the Camera Link connector on the Bobcat-640-CL module are shown in Figure 5-3 and Table 5-4.

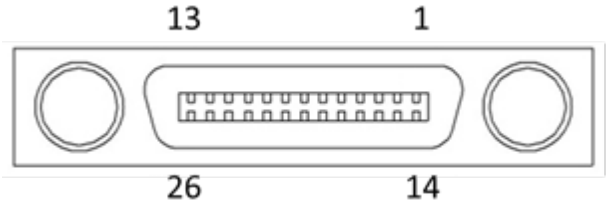

Figure 5-3 Pin out of camera link connector on the XSW-640-CL module

Pin	Signal	Pin	Signal
1	GND	14	GND
2	X0	15	X0+
3	X1	16	X1+
4	X2	17	X2+
5	XCLK	18	XCLK+
6	X3	19	X3+
7	SerTC+	20	SerTC-
8	SerTFG-	21	SerTFG+ P
9	CC1	22	CC1+
10	CC2+	23	CC2
11	CC3	24	CC3+
12	CC4+	25	CC4
13	GND	26	GND

Table 5-4 Camera link connector (base) pin assignment

CC1 can be configured as trigger input.

CC2 to CC4 in Table 5-4 are not supported by the module. The clock rate is 40 MHz with one tap & 16 bit/pixel.

i More info about the timing diagram can be found in (Ref. 5).

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6. Software Installation

Before being able to start the camera, the Xeneth imaging suite (at least version 2.4) and its graphical user interface must be installed, so that the data coming from a wide variety of Xenics detectors and cameras can be easily operated on and analyzed.

6.1. Xeneth Installation

It is a good practice to first uninstall a previous Xeneth version when installing a new one.

Refer to the Xeneth Installation Manual (Ref. 9) that is delivered on the CD together with the camera to install Xeneth.

When using camera link cameras, it is also necessary to pre-install the frame grabber before installing Xeneth! Refer to the frame grabber manual for installation instructions.

6.2. SDK Installation

The optional SDK installation is delivered on the CD together with the camera. Install the SDK software using this file.

After the SDK installation, the SDK manual, together with the samples and header files can be found in the C:\Program Files\Xeneth\SDK directory.

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7. Appendices

7.1. Appendix A

A detailed description of the Xenics Serial Protocol can be found in (Ref. 1)

7.2. Appendix B

The complete mechanical drawing of the Bobcat-640-GigE and CL can be found in (Ref. 2)

7.3. Appendix C

More detailed information on the Auto Gain Control functionality is provided in (Ref. 3)

7.4. Appendix D

More detailed information on the Auto Exposure Control functionality is provided in (Ref. 4)

7.5. Appendix E

The command and control register set and the camera functions and features for the Bobcat-640-GigE/CL are described in more detail in (Ref. 5).

7.6. Appendix F

The network connection set-up and the camera functions and features for the Bobcat-640-GigE are described in more detail in (Ref. 6).

7.7. Appendix G

The achievable frame rate and the minimal required frame time can be calculated using the Frame rate calculator in (Ref. 7).

7.8. Appendix H

The contrast of the image can be changed using the histogram equalization algorithm as described in (Ref. 8).

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